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WATER QUALITY CONTROL STUDY LOWER SHOSHONE RIVER BASIN WYOMING

Federal Water Pollution Control Administration
Kansas City, Missouri

February 1968

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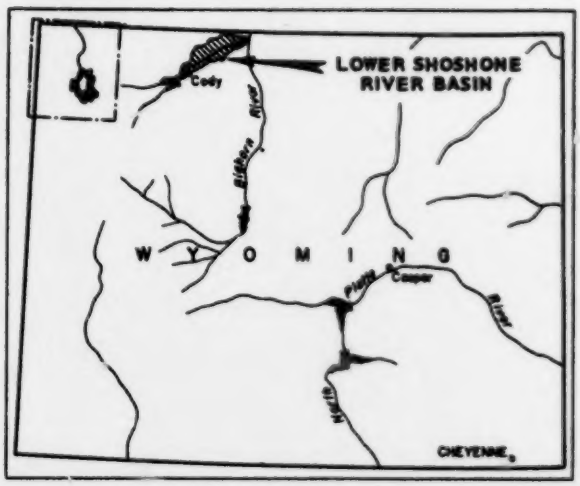

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UNITED STATES
DEPARTMENT OF THE INTERIOR
Federal Water Pollution Control Administration
Kansas City, Missouri

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WATER QUALITY CONTROL STUDY

LOWER SHOSHONE RIVER BASIN

WYOMING

Prepared at the request of and in cooperation with the
Bureau of Reclamation, Region 6,
U.S. Department of the Interior
Billings, Montana

U. S. Department of the Interior
Federal Water Pollution Control Administration
Missouri Basin Region
Kansas City, Missouri

February 1968

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I. INTRODUCTION

Request and Authority

The Bureau of Reclamation, Region 6, Department of the Interior, in a letter dated March 18, 1966, requested the Federal Water Pollution Control Administration, Department of Health, Education and Welfare, to review the water quality aspects of the Bureau's proposed Shoshone Extension Unit.[1/] This responsibility was set forth in the Federal Water Pollution Control Act, as amended (33 U.S.C. 466 et seq.).

In a second request dated May 3, 1967, the Bureau stated that in modifying the existing spillway at Buffalo Bill Reservoir, there was a possibility to provide additional conservation storage for water quality control or other purposes. As a result, the Bureau requested an indication of the value of increased releases for pollution abatement.

Purpose and Scope

The purpose of this study is to evaluate the probable effect of the proposed project on water quality in the lower Shoshone River Basin and in Yellowtail Reservoir on the Bighorn River; to ascertain the benefits or damages resulting from changes in water quality; to assess the suitability of the water for proposed water uses; and, to determine water quality control needs. The study area includes the lower Shoshone River Basin in Park and Big Horn Counties in Wyoming and a portion of the Bighorn River Basin in Big Horn County, Wyoming and Big Horn County, Montana.

1/ Responsibilities for these activities were transferred to the Department of the Interior by Reorganization Act No. 2 of 1966, effective May 10, 1966.

The conclusions presented are preliminary and subject to revision, pending completion of the Federal Water Pollution Control Administration's Missouri-Souris-Red River Basin Comprehensive Water Pollution Control Project.

Acknowledgements

The assistance and cooperation of State and Federal agencies and individuals are gratefully acknowledged by the Federal Water Pollution Control Administration. Particular appreciation is expressed to the following for data and advice furnished by their staff members.

U. S. Bureau of Reclamation, Region 6
Regional Office, Billings, Montana

U. S. Geological Survey
Cheyenne and Worland, Wyoming

Wyoming State Department of Public Health
Cheyenne, Wyoming

II. SUMMARY OF FINDINGS AND CONCLUSIONS

Findings

1. The Bureau of Reclamation's proposed Shoshone Extension Unit, in the northeast corner of Park County, Wyoming, will include the diversion of 64,300 acre-feet of water annually from the existing Buffalo Bill Reservoir on the Shoshone River for irrigation of 19,200 acres of land; 18,000 acres of Polecat Bench and 1,200 acres in the adjacent Frannie Loop area. Holden Reservoir (9,900 acre-feet capacity) located in the middle of Polecat Bench, would be used to store excess water including irrigation return flows for application on lower lying lands.

2. The Bureau of Reclamation proposes to modify the existing spillway at Buffalo Bill Reservoir to provide additional conservation storage for pollution abatement, municipal and industrial water supply, fishery enhancement or some combination of services.

3. Cody (4,838), Lovell (2,451); and Powell (4,740) are the main population centers of the basin. Irrigated agriculture, livestock production, oil and gas production, and tourist trade are the major sources of income in the Shoshone River Basin. In 1959 there were about 127,000 acres of land irrigated from the Shoshone River.

4. The Shoshone River drains an area of about 2,990 square miles. Most of the precipitation occurs in the western portion of the basin, which is mountainous. The inflow to Buffalo Bill Reservoir has averaged about 920,000 acre-feet annually. Streamflows are regulated

by Buffalo Bill Reservoir and are affected by diversions for irrigation.

5. Water quality in Buffalo Bill Reservoir is excellent for most uses, with concentrations of total dissolved solids (TDS) usually less than 200 milligrams per liter (mg/l). Water quality deteriorates downstream due to the effects of return flows from irrigation, natural sources of pollution, and oil field wastes. The time weighted average TDS concentration in the Shoshone River at Kane in the 1965 water year was 695 mg/l. The Bighorn River at Kane in water year 1965 averaged 632 mg/l. Mineral concentrations are usually at their maximum during periods of low streamflow in the winter. Under such conditions concentrations of sulfates and TDS have exceeded 600 mg/l and 1,400 mg/l, respectively, at various points in the Shoshone River.

6. Lovell, Wyoming, obtains its municipal water from the Shoshone River just upstream from Sage Creek. At times due to relatively high concentrations of sulfates, hardness and total dissolved solids, the water is considered to be too poor in quality for municipal use.

7. Byron, Cody, Lovell, and Powell use oxidation lagoons to treat their municipal wastes before discharge to the Shoshone River. Industrial wastes include cannery wastes at Cowley, sugar beet mill wastes at Lovell, oil refining wastes at Cody, and various oil field wastes. The Wyoming State Department of Public Health has requested the sugar beet mill to provide additional waste treatment.

8. Arnoldus Lake, located about two miles to the west-northwest of Byron, receives oilfield wastes and seepage from a nearby canal and

laterals. Total dissolved solids concentrations in the lake vary, depending on the amount of seepage from the canal and the evaporation losses from the lake. At times, TDS concentrations have been as high as 8,000 mg/l.

Conclusions

1. Municipal wastes, the cannery wastes at Cowley, the sugar beet mill wastes at Lovell, and the refinery wastes at Cody can be adequately treated at their sources to prevent deterioration of water quality. Therefore, low flow augmentation will not be required to assimilate these municipal and industrial waste loads.

2. Operation of Buffalo Bill Reservoir to supply existing development and the proposed Shoshone Extensions Unit would result in an average increase of about 60 mg/l in total dissolved solids and 25 mg/l in hardness at Lovell's water supply intake during the period of October through March. During drought years, TDS concentrations may become as high as 1,400 mg/l, with corresponding sulfate concentrations of more than 500 mg/l. Changes in water quality during the irrigation season are not expected to be this great, and the water quality during this period will be suitable for municipal use.

3. It is anticipated that return flows from the additional irrigated land, which will enter the Shoshone River below the Lovell water intake, will cause an increase in hardness of approximately 13 mg/l at Hardin, Montana.

4. Annual damages resulting from increased hardness are attributable to the project. The damages are based on increased amounts of soap, synthetic detergents and other cleansers necessary in household and commercial cleaning operations at Lovell, Wyoming and Hardin, Montana. It is estimated that these damages will be $1,200 annually under present day conditions increasing to $4,000 annually by the year 2070.

5. Except for the water supplies at Hardin, Montana and Lovell, Wyoming, the anticipated changes in water quality resulting from project revisions would have only minor effects on other present water uses including existing irrigated agriculture.

6. There is a need, depending upon the quality and amount of the irrigation return flow and mineralization from natural sources entering the stream, for flow augmentation to reduce mineral concentrations at Lovell. To maintain satisfactory water quality under critical conditions a total flow of approximately 670 cubic feet per second (cfs) is needed at the Lovell water intake. Based upon expected operation, the additional releases required will range from 100 cfs to almost 200 cfs under average conditions to over 500 cfs in a critical year and near zero as a minimum. For the most severe conditions a storage of approximately 159,000 acre-feet will be required. Storage needed for the years 1959, 1960, 1961 and 1962 will average 70,400 acre-feet.

7. If the computed streamflow regulation is provided, benefits would accrue through improved quality at Lovell, Wyoming, due to savings in soap, detergents, and general household cleansers from the reduction

in hardness. The annual value of these benefits is estimated to be $1,000 at present, increasing to $3,000 by 2070. The streamflow regulation is expected to have little net affect on the water supply at Hardin, Montana.

8. The conclusions presented are preliminary and subject to revision, pending completion of studies by the Missouri-Souris-Red River Basins Comprehensive Water Pollution Control Project being conducted in this region by the Federal Water Pollution Control Administration.

III. PROJECT DESCRIPTION

The proposed Shoshone Extension Unit is located in the northeast corner of Park County, Wyoming. The primary purpose of this unit is to supply water for the irrigation of 19,200 acres of land on Polecat Bench (18,000 acres) and in the adjacent Frannie Loop area (1,200 acres). Polecat Bench is located immediately north of the developed Shoshone Project of the Bureau of Reclamation. The Frannie Loop area is located below and to the northeast of Polecat Bench.

The proposed project represents a physical extension of the Shoshone Project, but would be undertaken as a part of the Missouri River Basin Project. A total of 67,300 acre-feet of water will be diverted annually from the existing Buffalo Bill Reservoir on the Shoshone River. The water will be conveyed to Polecat Bench through the existing Shoshone Canyon Conduit and Heart Mountain Canal and through a proposed series of siphons and a short tunnel.

At the tunnel inlet, the proposed Polecat Canal will deliver water for 3,100 irrigable acres to be supplied by pumping, including a small relift area on the high point of the bench. After leaving the tunnel, 8,040 acres would be served by the Polecat Canal system. The canal will terminate in the proposed Holden reservoir, total capacity 9,900 acre-feet, near the midpoint of the bench. Flows into this reservoir will include return flows mostly from the areas served by pumping.

Originating at the reservoir, Holden Canal with its several

laterals will complete the deliveries (on the bench) to 6,860 irrigable acres. One of the laterals would receive a second diversion from the trunk drain. After capturing remaining flows in the drain, at the northeast end of the bench, Holden Canal will drop to the Frannie Loop area of 1,200 acres. The reuse of a portion of the return flows will result in a more efficient use of water. The final return flows from the project will reach the Shoshone River via Sage Creek. In addition to irrigation of new land, the proposed development will provide fish and wildlife resources and recreation opportunities at Holden Reservoir.

In addition, storage enlargement studies are underway on Buffalo Bill Reservoir. In modifying the existing spillway for modern-day flood probabilities, additional conservation storage can be provided for added irrigation, municipal and industrial water supply, fishery enhancement, for pollution abatement or for some combination of these services.

IV. DESCRIPTION OF STUDY AREA

The Shoshone River is a major tributary of the Bighorn River. Originating in the mountains to the west of Cody, Wyoming, it flows northeast through Park County and a portion of Big Horn County, Wyoming, draining an area of about 2,990 square miles. Elevations in the Shoshone River Basin range from over 12,000 feet in the western portion of the basin to about 3,600 feet at the confluence with the Bighorn River. The climate is typical of the area, with low precipitation, low relative humidity, wide temperature range, cold and moderately long winters. Except for the mountainous areas to the west of Cody, annual precipitation averages about six inches per year. Irrigated agriculture, livestock production, oil and gas production, and tourist trade are the major sources of income in the basin. In 1959 there were about 127,000 acres of land irrigated from the Shoshone River. In 1960 the population of Big Horn and Park Counties was 28,722 with about 21,000 living in the Shoshone River Basin. Cody (4,838), Lovell (2,451) and Powell (4,740) are the main population centers of the basin.

V. WATER RESOURCES OF THE STUDY AREA

Quantity of Water Available

The major source of water within the Shoshone River Basin is runoff from the mountainous area to the west of Cody. The annual inflow to Buffalo Bill Reservoir, which has an active storage capacity of about 373,000 acre-feet, has averaged 920,100 acre-feet from 1916 through 1963. From the reservoir the water is either discharged to the river (some of it through power plants) or is diverted to the Heart Mountain Division of the Bureau of Reclamation's Shoshone Project. Diversions to the Heart Mountain Division began in about 1950.

Table I gives a summary of streamflow data for various points in the Shoshone River Basin below Buffalo Bill Reservoir and the Bighorn River at Kane, Wyoming. Diversions for irrigation, spills from canals, and irrigation return flows have a significant effect on streamflows. A major diversion immediately upstream from the gaging station on the Shoshone River near Garland is the major reason that the average flow at that point is less than the average flows at Byron and Kane. Many of the canals divert more water than is needed, with the excess being discharged back to the river at various points along the canals. In many portions of the basin irrigators receive 6-7 acre-feet of water per acre per year, while calculations by the Bureau of Reclamation show that there is only a need for about 4 acre-feet. Most of the extra water usually returns to the river as surface runoff from irrigation.

This practice of using excess water will probably continue for as long as the extra water is cheaper than the additional labor needed to use water efficiently. The flows of Bitter Creek and Sage Creek consist primarily of irrigation return flows.

TABLE I

SUMMARY OF STREAMFLOW DATA[1/]

Station	Period of Record	Min. cfs	Max. cfs	Average cfs	Average Acre-feet/yr.
Shoshone River below Buffalo Bill Reservoir	1951-1964[2/]	59		1,106	801,500
Shoshone River near Garland, Wyoming	5/58-9/64	5	9,550	508	367,800
Bitter Creek near Garland, Wyoming	3/50-12/53 10/57-9/60	4	487	134	97,000
Shoshone River at Byron, Wyoming	1/29-9/64	29	16,000	913	661,000
Sage Creek near Lovell, Wyoming	4/51-9/60	10	1,290	106	76,740
Shoshone River at Kane, Wyoming	10/57-9/64	120	13,200	1,081	782,600
Bighorn River at Kane, Wyoming	8/28-9/64	176	25,200	2,218	1,606,000

1/ United States Geological Survey

2/ This period of record chosen to include effect of diversions to Heart Mountain Canal.

Quality of Water Available

Table II summarizes most of the available data for the mineral composition of surface waters of the Shoshone River Basin. This includes data from both the U. S. Geological Survey (USGS) and the Wyoming State Department of Public Health. Calcium, magnesium, and sodium are the major cations, while bicarbonate and sulfate are the predominate anions. Chloride concentrations are generally less than 50 milligrams per liter (mg/l).

The water in Buffalo Bill Reservoir usually has a total dissolved solids (TDS) concentration of less than 200 mg/l. Along the Shoshone River between Buffalo Bill Dam and the City of Cody there are several springs. Sulfur odor is prominent in the vicinity of these springs. A sample collected from one of these springs (May, 1966) had a temperature of 27°C and a specific conductance (Ec) of 1,800 micromhos (umhos) at 25°C.[1/] The Bureau of Reclamation estimates the total flow of these springs at about 35 cfs.

The data in Table II indicates a general increase in TDS concentrations as the water moves downstream from Buffalo Bill Reservoir. This is to be expected since most of the water entering the river downstream from the reservoir consists of irrigation return flows and spills from canals. At any given point the lowest TDS concentrations usually occur during the period of high streamflows in June and July, while the highest TDS concentrations

1/ Note: All specific conductance readings are expressed in terms of equivalent values at 25°C.

usually occur during the winter when stream flows are normally the lowest. This is especially true for such tributaries as Bitter, Whistle, and Sage creeks.

TABLE 11

Summary of Water Quality Data for Surface Waters[1]

Station	Period of Record	No. of Samples[2]		Flow (cfs)	Ca	Mg	Na	HCO_3	SO_4	Cl	TDS	Hardness	EC[3]
				Units: Milligrams per liter except as noted									
Shoshone River below Buffalo Bill Reservoir	1948, 1949, 1961, 1965		Low	180	11	2	5	54	14	1	92	37	117
			High	9370	152	37	41	447	290	10	736	531	1060
			Wt. Avg.[4]	1140	18	4	14	74	28	2	124	60	178
Shoshone River at Cody, Wyoming[5]	12/12/63-3/20/64	14	Low	-	59	22	25	207	106	4	372	237	-
			High	-	84	38	41	656	148	11	490	312	-
			Avg.	-	73	28	30	282	132	8	444	293	-
Shoshone River below Cody, Wyoming	10/50-7/53	16-31	Low	-	22	4	13	75	39	2	163	73	216
			High	-	256	131	389	343	1650	29	1350	1180	3210
			Avg.	-	69	21	56	176	214	9	605	259	693
Alkali Creek at Ralston, Wyoming	12/49-7/53	8-15	Low	-	26	14	7	127	77	3	254	104	370
			High	-	75	58	251	340	613	56	1070	421	1740
			Avg.	-	50	38	117	227	326	24	581	267	1046
Shoshone River at Penrose Dam[5]	12/9/63-3/18/64	14	Low	-	60	21	52	211	168	9	486	250	-
			High	-	88	47	90	268	276	41	720	365	-
			Avg.	-	77	35	70	244	232	14	650	337	-
Shoshone River near Garland, Wyoming	8/58-10/59	14	Low	2	31	11	31	127	77	2	261	124	330
			High	2250	153	75	185	379	697	26	1440	691	1860
			Avg.	454	79	31	92	241	302	10	682	322	961
Bitter Creek near Garland, Wyoming	12/49-9/53 8/58-9/60	37-43	Low	15	39	14	93	192	198	6	508	183	750
			High	388	93	40	425	398	915	21	1680	369	2270
			Avg.	141	68	26	206	279	457	13	927	276	1352
Bitter Creek[5]	12/9/63-3/18/64	15	Low	-	57	28	245	238	490	18	1076	302	-
			High	-	84	56	320	372	723	50	1412	378	-
			Avg.	-	74	40	274	332	572	26	1233	350	-
Whistle Creek near Garland, Wyoming	7/59-5/60	8	Low	2	52	16	66	157	226	4	482	195	713
			High	45	273	164	1370	526	3760	105	6370	1330	6960
			Avg.	25	126	67	499	277	1374	35	2384	591	2832
Shoshone River at Byron, Wyoming	1948, 1949, 1965	1	Low	398	9	5	19	90	45	1	163	81	249
			High	6080	100	49	108	292	293	14	713	373	1020
			Wt. Avg.[4]	979	52	14	58	176	158	7	416	190	590
Lovell Water Supply Intake[5]	12/9/63-3/18/64	15	Low	-	59	25	78	204	211	11	572	265	-
			High	-	96	49	120	293	335	43	832	400	-
			Avg.	-	81	38	90	254	289	19	734	357	-
Sage Creek at Sidon Canal	8/58-5/60	19	Low	1	86	35	127	191	447	11	844	362	1190
			High	208	402	281	1240	700	4180	55	6850	2160	7090
			Avg.	75	179	107	410	325	1449	27	2508	887	2908
Sage Creek near Lovell, Wyoming	12/49-7/53	8-17	Low	14	108	48	197	193	673	16	1220	468	1590
			High	195	336	233	964	491	3190	81	5100	1760	5630
			Avg.	106	221	150	568	322	1947	37	3078	1167	3724
Shoshone River at Kane, Wyoming	10/50-6/53 8/58-9/65	118-131	Low	-	31	10	27	113	75	2	226	117	355
			High	-	185	81	288	450	990	32	1840	796	2540
			Avg.	-	92	36	122	240	400	12	828	366	1178
Bighorn River at Kane, Wyoming	1956, 1957, 1962[6]		Low	475	63	11	30	116	117	6	292	152	460
			High	2303	168	47	156	300	563	26	1110	524	1640
			Wt. Avg.	9610	76	24	86	190	287	14	620	290	890
Miscellaneous Samples													
Lovell City Water-Finished[5]	12/16/63-3/4/64	4	Low	-	34	27	91	64	317	18	586	215	-
			High	-	67	35	130	131	354	21	706	290	-
			Avg.	-	51	31	103	105	335	19	652	255	-
Arnoldus Lake[5]	11/26/63	1		-	504	278	1220	116	3545	713	6752	2600	-
Shoshone River above junction with Garland swamp discharge[5]	1/8/64	1		-	88	35	88	305	286	9	720	362	-
Swamp water below Arnoldus Lake discharge[5]	1/8/64	1		-	600	323	1148	162	3720	787	7128	2925	-
Shoshone River below Garland Oil Field[5]	1/8/64	1		-	60	60	116	229	353	25	820	398	-
Arnoldus Lake-Garland Oil Field[5]	1/8/64	1		-	358	185	1329	159	4218	908	8104	2975	-

Note: Averages are arithmetic means. Weighted averages are flow weighted and based on composite samples collected throughout the year.

1/ All data are from the U. S. Geological Survey unless otherwise noted.

2/ Complete analyses were not run on all samples. Therefore, the number of analyses used in determining the low, high, and average concentrations at each station may vary.

3/ Specific conductance at 25° C.

4/ Weighted average based on composite samples. Water years 1949 and 1949.

5/ "Water Quality Shoshone River," unpublished report by the Wyoming State Department of Public Health.

6/ Additional data is available. Data selected to show representative water quality in the Bighorn River at Kane, Wyoming.

Arnoldus Lake (This lake is described in more detail later in this report.) is located about two miles to the west-northwest of Byron, Wyoming. Data collected by the Wyoming State Department of Public Health during the winter of 1963-64 show that water in Arnoldus Lake and the nearby swamp, which receives drainage from Arnoldus Lake, has TDS concentrations in the range of 6,700 to 8,000 mg/l. During a field reconnaissance of the area in May, 1966, by personnel of the Federal Water Pollution Control Administration the following specific conductance values were observed:

Arnoldus Lake at outlet	4,500 µmhos.
Northern edge of swamp	2,600 µmhos.
Center of swamp	3,800 µmhos.

This improvement in quality is believed to be due to the dilutional effects of irrigation return flows and seepage from nearby canals. The swamp ultimately drains to the river, increasing the TDS concentration by an undetermined amount.

The City of Lovell's water supply intake is located on the Shoshone River just above the confluence with Sage creek. A summary of the chemical analyses of samples collected at this point by the Wyoming State Department of Public Health from December 1963 to March 1964 are included in Table II. The USGS water quality data for the Shoshone River at Byron is indicative of water quality at Lovell's water supply intake. The water quality data for the Shoshone River near Garland, about 7 miles upstream from Byron, were collected during a period of below average runoff and should be indicative of water

quality under these conditions. The data for the station near Garland show maximum sulfate and TDS concentrations of 697 mg/l and 1,440 mg/l, respectively in February, 1959. The data for the station at Byron show maximum concentrations of 293 mg/l and 713 mg/l, respectively occuring in the winter of 1965. Concurrent records are not available at these stations for direct comparison. At times, the City of Lovell has had problems with high sulfate concentrations in their water supply. The Public Health Service Drinking Water Standards, revised 1962, recommend that the concentrations of TDS and sulfates not exceed 500 mg/l and 250 mg/l, respectively, where other more suitable supplies are or can be made available. The setting of these standards are based primarily on consideration of taste. Cathartic (laxative) effects are commonly experienced with water having sulfate concentrations of 600 to 1,000 mg/l, particularly if much magnesium or sodium is present. However, with time, people become physiologically acclimatized to water of this quality. New users, such as travelers, may still be adversely affected.

Published data on the quality of ground waters in the Shoshone River Basin are limited, with essentially all of it contained in USGS Water Supply Paper Number 1418. The data in this publication are based on 21 samples collected from 16 points in the Heart Mountain Division of the Shoshone Irrigation Project, which is located between Cody and Polecat Bench. The samples were collected in 1946 and 1950, which were the early stages of development of the Heart Mountain Division. Concentrations of TDS ranged from 346 mg/l to 6,360 mg/l, with all but

three samples having concentrations greater than 1,000 mg/l. Sulfate and bicarbonate were the major anions, with the major cations being calcium, magnesium, and sodium. In eight out of 21 samples the iron concentration was greater than 0.30 mg/l, with the maximum concentration being 9.1 mg/l. Nitrate (NO_3) concentrations were greater than 100 mg/l in three samples, with the remaining samples having concentrations less than 45 mg/l. Seepage from a barnyard and/or the leaching of fertilizers were considered as possible causes of the high nitrate concentrations.

Because of the excellent quality of the water diverted from Buffalo Bill Reservoir it was predicted that with time there would be a general improvement in the quality of the ground water in the irrigated areas of the Heart Mountain Division. This appears logical, although it is not known how long it will take before there is a significant change in quality. Unfortunately, data are not available to show the changes in quality that have occurred to date.

Water Uses

Irrigation is by far the largest user of water within the Shoshone River Basin, with about 127,000 acres of land irrigated from the Shoshone River. Buffalo Bill Reservoir provides trout fishing and water based recreation. The 2.5 miles of the Shoshone River immediately below Buffalo Bill Dam provide good fish habitat except when releases from the reservoir are at a minimum, 15 cfs. Under low flow conditions gases from the springs along the river have been toxic to fish. The U. S. Fish and Wildlife Service has recommended that a minimum

instantaneous release of 100 cfs be maintained from Buffalo Bill Reservoir into the Shoshone River Canyon. This minimum flow would prevent the occurrence of conditions which are toxic to fish and it would improve the fish habitat below the reservoir. Fishing activity is not extensive along the river from Cody to the confluence with the Bighorn River. The municipal water supplies within the basin are listed in Table III. Domestic water supply for rural residents is obtained from individual wells. Wells are also the primary source of water for livestock.

TABLE III

V-11

Municipal Water Supply[1/]

City	Population Served	Source	Treatment
Byron	417	Wells	Chlorination
Cody	5,200	Cody Canal and storage reservoirs	Chemical coagulation, filtration, chlorination
Cowley	460	Shoshone Canal	Filtration, chlorination
Deaver	120	Heart Mountain Canal	Filtration, chlorination
Frannie	171	Artesian Well	Chlorination
Lovell	2,500	Shoshone River	Chemical coagulation, softening, filtration, chlorination
Powell	4,740	Well and collection gallary	Chlorination
Hardin[2/]	3,000	Bighorn River	Chemical coagulation, softening, filtration, chlorination

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1/ Data from 1963 Inventory Municipal Water Facilities, U. S. Department of Health, Education, and Welfare, Public Health Service

2/ Hardin, Montana. All other cities located in Wyoming

VI. ECONOMY

Past and Present

The economy of the study area is dominated by agriculture. Processing of agricultural products, gas and petroleum production and refining, and tourism are important industries also.

The 1960 population of the study area was approximately 25,000. About 12,000 lived in the three population centers of Cody (4,800), Lovell (2,500), and Powell (4,700). The remaining 13,000 were classified as rural farm or rural non-farm residents.

The basins total employment in 1960 was approximately 8,825. About 5.9 percent of the total population (520) were engaged in manufacturing. Another 20.1 percent (1,765) were in agriculture while 20.1 percent (1,774) were employed in other commodity producing industries. The largest sector was the non-commodity producing area which employed about 54.0 percent (4,765).

Two heavy water using and waste producing industries in the study area employ over 60 percent of the total manufacturing employment in the basin. One is a large petroleum refinery at Cody and the other is a major sugar beet refinery at Lovell.

In 1959 there were about 127,000 acres of land irrigated from the Shoshone River. Almost all (99 percent) of the cropland in the basin was irrigated. The principal cash crops were dry beans and sugar beets. The main source of farm income is derived from the sale of livestock. Approximately 46 percent of all cropland harvested

in 1959 were used to produce alfalfa and various other types of domestic and wild hays.

There are large petroleum and natural gas fields in the basin. Park County has a reserve of over 100 million barrels while Big Horn County's reserve is slightly less.

Tourism is another important industry in the basin. A major highway crossing the basin carries tourists and vacationers to Yellowstone National Park.

Future

The population of the study area is projected to increase to about 28,000 by 1970; 61,400 by 2020, and to 139,000 by 2070. Disaggregation of population projections appear in the following table:

	1970	2020	2070
Cody	6,000	19,000	58,000
Lovell	2,700	4,400	7,000
Powell	5,600	13,000	30,000
Total Urban	14,300	36,400	95,000
Rural	14,500	25,000	44,000
Total Population	28,800	61,400	139,000

VII. WATER QUALITY CONTROL

Sources of Pollution

Municipal waste discharges within the basin are listed in Table IV. The waste loadings from municipal sources are insignificant when considering the treatment provided and the streamflows that normally occur at the points of waste discharge.

A summary of industrial waste discharges within the basin is shown in Table V. Although the present waste loadings from these industrial sources are not known, only one significant water quality problem has been attributed to these waste discharges. The Wyoming State Department of Public Health has requested the sugar beet mill at Lovell to provide additional waste treatment in the form of solids reduction in the flume water. Any of these wastes will cause water quality problems if adequate treatment is not continously provided. The cannery wastes at Cowley and the sugar beet mill wastes at Lovell are seasonal in nature, but are characterized by high biochemical oxygen demand (BOD) concentrations. Oil refinery wastes frequently contain phenolic compounds, which, in concentrations in excess of 0.001 mg/l, can cause taste problems in municipal water supplies. Adequate treatment at the source can prevent the occurrence of water quality problems at present levels of flow. The oil field wastes consist primarily of brackish water and small amounts of petroleum. Data collected by the Wyoming State Department of Public Health show that oil field wastes from oil fields operated by Mobil, Marathon,

and Texaco had a combined average flow of 2 cfs and a flow weighted average TDS concentration of 3,260 mg/l.[1/] Except under low flow conditions this would have little effect on water quality in the Shoshone River.

1/ "Water Quality Shoshone River," unpublished report by the Wyoming State Department of Public Health

TABLE IV

Municipal Waste Discharges

City	1960 Population	Treatment	Receiving Stream	P.E.[1] Discharged to Water Course
Byron[2]	417	Oxidation Lagoons	Shoshone River	40E
Cody[2]	4,838	Oxidation Lagoons	Shoshone River	500E
Cowley	459	Pvt. Disposal Facilities	---	None
Lovell[2]	2,451	Oxidation Lagoons	Shoshone River	250E
Powell[2]	4,740	Oxidation Lagoons	Shoshone River	400E
Frannie	171	Oxidation Lagoon	Sage Creek	---

1/ Population Equivalent

2/ Data from 1962 Inventory Municipal Waste Facilities, U. S. Department of Health, Education, and Welfare, Public Health Service, Division of Water Supply and Pollution Control

TABLE V

Industrial Waste Discharges[1/]

Source	Nature of Wastes	Treatment Provided
Husky Oil Co. Cody, Wyo.	Oil Refining	Oil Separator: Lagoons
Wyoming-Gulf Cody, Wyo.	Sulfur Reduction	Lagoon
Big Horn Canning Cowley, Wyo.	Vegetable Canning	Broad Field Irrigation Planned
Stanolind Oil Cowley, Wyo.	Sulfur Reduction	Oil Separator
Garland Oil Cowley, Wyo.	Oil Field Wastes	Oil Separator
Great Western Sugar Co. Lovell, Wyo.	Beet Sugar Mill	Lagooning of Lime Wastes[2/]

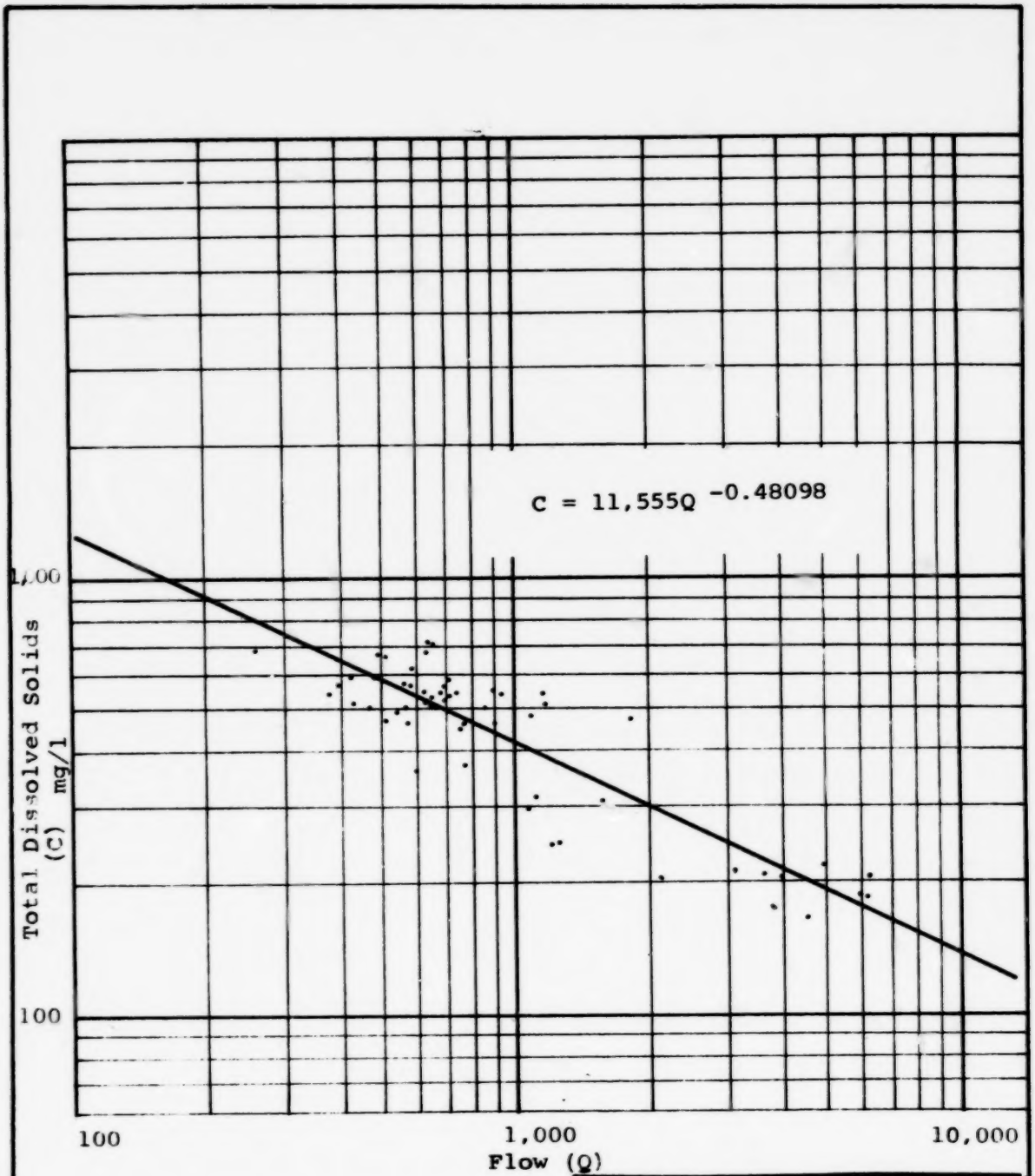
1/ Data from files of Federal Water Pollution Control Administration

2/ The Wyoming State Department of Public Health has requested that additional treatment be provided; namely screening, settling, and a pulp dryer.

There is natural oil seepage to the Shoshone River just downstream from Cody. This might be the cause of the oily taste in fish caught in that area. Wastes from the refinery at Cody could also contribute to the problem. During the irrigation season an oily black sludge--like material settles out behind Willwood Dam, a diversion dam on the Shoshone River about 12 miles downstream from Cody. From early November to mid-December, the gates of the dam are opened, flushing the deposits from behind the dam. The river flows through the gates for the remainder of the winter. Taste and odor problems in the water supply at Lovell attributable to this material have been reported.

Arnoldus Lake is a natural depression located about two miles to the west-northwest of Byron, Wyoming. The lake is shallow and has an estimated surface area of 200 acres. The water in the lake comes primarily from two sources: seepage from Sidon Canal and nearby laterals; and oil field wastes. The total inflow to the lake from these various sources is not known. The high salt concentrations in the lake, up to 8,000 mg/l TDS, are due in part to the brackish oil field wastes, and in part due to the concentrating effect of evaporation losses.

To prevent Arnoldus Lake from overflowing onto irrigated land the Soil Conservation Service (SCS) installed a 24" tile drain from the lake to a swamp located below the lake and on the flood plain of the river. An irrigation tile drain ties into the drain from the lake before it reaches the swamp. In addition to the drain, the swamp



WATER RESOURCES STUDY

Lower Shoshone River Basin
Wyoming

Discharge vs. Total Dissolved Solids
Shoshone River at Byron, Wyoming

U.S. DEPARTMENT OF THE INTERIOR
Federal Water Pollution Control Administration
Missouri Basin Region, Kansas City, Missouri

Figure 1

also receives return flows from nearby irrigated lands and oil field waste discharges located below the lake. The swamp ultimately drains to the Shoshone River. Its effect on water quality in the river has not been determined.

Irrigated agriculture has a significant effect on water quality in the lower Shoshone River Basin. Of the total annual salt load of about 800,000 tons in the Shoshone River at Kane, approximately 40 percent comes from the following sources: upstream from Buffalo Bill Reservoir; springs along the Shoshone River below Buffalo Bill Reservoir; and various oil field wastes. Natural sources of pollution and the additional salts leached from the soil by irrigation waters account for most of the remaining 60 percent of the total salt load. Assuming an equal contribution by irrigation and natural sources, irrigation would contribute almost two tons of salts per irrigated acre. In addition, the salt concentrations are further increased more by the evapotranspiration losses of water than occur with irrigation. It is estimated that the combined effects of existing irrigation in the Shoshone River Basin cause approximately an 80 percent increase in salt concentrations in the Shoshone River at Kane as compared to the concentrations that would exist without irrigation.

Future Water Quality

Development and operation of the proposed Shoshone Extension unit would result in an increase in mineral concentrations in portions of the Shoshone and Bighorn Rivers. Since the water in Buffalo Bill Reservoir is of substantially better quality than points further downstream, the diversion of water from the reservoir to Polecat Bench

would result in higher mineral concentrations in the river at all points below the reservoir. Evapotranspiration losses from irrigation and additional leaching of salts would also contribute to increased mineralization.

Projections of changes in water quality due to project development were made for the Shoshone River at Byron, Shoshone River at Kane, and the Bighorn River below the Shoshone River. The changes in quality at Byron should be approximately the same as those that would occur at Lovell's water supply intake. Projection of water quality at Byron was based on anticipated changes in streamflow due to project development. The Bureau of Reclamation's computer studies of proposed future operation of Buffalo Bill Reservoir with Polecat Bench were used in determining anticipated changes in streamflow. Due to the numerous diversions, canal spills, and irrigation return flows, it is not known what effect project development would have on streamflows at Byron during the irrigation season. Projections of water quality were limited to the period of October through March.

Although at this time it is not possible to make reliable projections of the changes in water quality that would occur at Byron during the irrigation season, it is anticipated that there would be no significant changes and the water would still be suitable for municipal use. Normally an excess of water is diverted for irrigation and part of the water is returned to the river only slightly degraded in quality. This serves to dilute the more concentrated return flow.

Projection of water quality at Byron was based upon the flow vs. quality relationship which has been established and is shown on Figure I. An increase from pre-project to project conditions is projected in total dissolved solids concentrations. This increase, averaging about 60 mg/l, is based on the operation studies furnished by the Bureau of Reclamation for the most critical period of drawdown (1959-1962).

Additional water diverted for municipal and industrial uses above Lovell will reduce streamflows and increase mineral concentrations. As return flow characteristics are not known, however, the magnitude of the increase has not been projected.

Effects of Change in Water Quality

Project operations will result in an increase in the total dissolved solids in the stream. The effects of this added mineralization is measured primarily in the effects of hardness, which constitutes about 45 percent of the dissolved minerals. The added hardness will cause an increase in the consumption of soap, synthetic detergents and other cleansers used in household and commercial cleaning operations. According to DeBeer & Larson, an increase of 100 mg/l hardness as $CaCO_3$ will result in an added cost of approximately $1.15 per capita on an annual basis.1/

It is estimated that these damages will be $1,200 annually under present day conditions increasing to $4,000 annually by the year 2070. 2/

1/ Journal of the American Water Works Association, Water Hardness and Domestic Use of Detergents, L. M. DeBeer and F. E. Larson, July, 1961.

2/ In 1959-1960 constant dollars

Water Quality Control Needs

Except for the water supplies at Lovell, Wyoming and Hardin, Montana the anticipated changes in water quality resulting from development of the Shoshone Extension Unit would have minor to insignificant effects on present water users. The effects on existing irrigated agriculture would be insignificant.

At times under existing conditions the quality of Lovell's water supply is considered poor for municipal use. Obviously a further deterioration in quality, such as that which would occur with development of the Shoshone Extension Unit, is undesirable. With development of the Shoshone Extension Unit, Lovell would probably continue to use the same source of supply, although during periods of low streamflow the water quality would be marginal for municipal use.

However, with additional conservation storage in Buffalo Bill Reservoir, releases could be provided during the period beginning in October and extending through most of March which would serve to dilute irrigation returns flows to an acceptable level of concentration for municipal water supplies. Such releases would also enhance the fishery potential of the river and have a beneficial effect on Yellowtail Reservoir on the Bighorn River.

Releases in addition to those proposed from Buffalo Bill Reservoir will be required to maintain satisfactory water quality at Lovell. Based upon the flow vs. quality relationship shown in Figure I, a flow of approximately 670 cfs will be needed to maintain satisfactory water

quality. The amount of the release will depend upon the quality and amount of irrigation return flow and mineralization from natural sources entering the stream. Based upon expected operation, the additional releases required will vary from 100 cfs to almost 200 cfs under average conditions to over 400 cfs in a critical water year and down to near zero as a minimum. For the most severe conditions a storage of approximately 159,000 acre-feet will be required.

Benefits for Flow Regulation

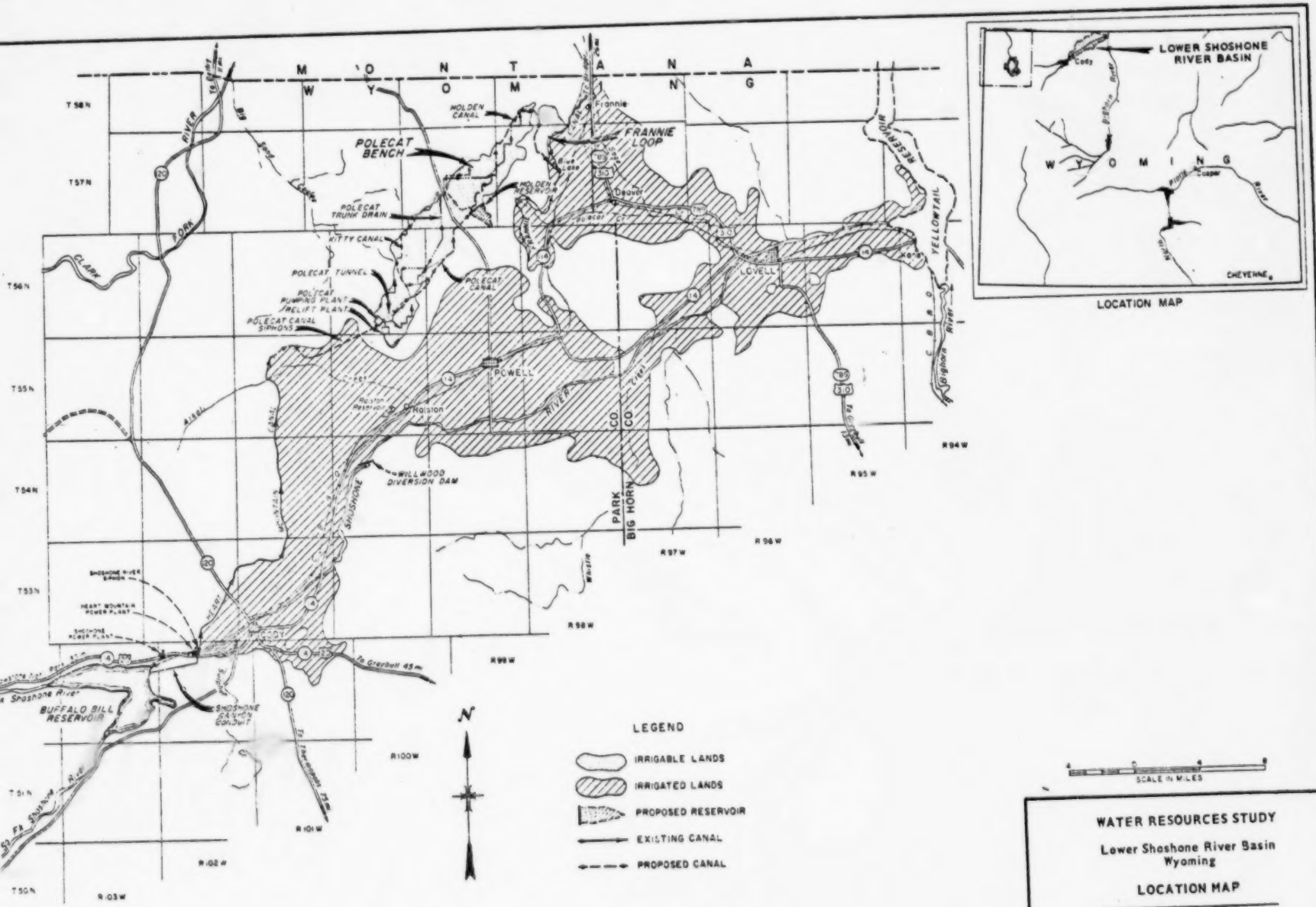
Benefits have been calculated to estimate the worth of flow regulation, should water be available for that purpose.

The benefits would accrue through improved water quality at Lovell, Wyoming, due to reduction in hardness and subsequent savings in soap, synthetic detergents and cleansers.

The annual value of these benefits is estimated to be $1,000 at the present time increasing to $3,000 by 2070.[1/]

Little effect is expected on the water supply at Hardin, Montana.

1/ In 1959-1960 constant dollars



WATER RESOURCES STUDY

Lower Shoshone River Basin
Wyoming

LOCATION MAP

U.S. DEPARTMENT OF THE INTERIOR
Federal Water Pollution Control Administration
Missouri Basin Region, Kansas City, Missouri

BR MAP NO 548-601-1598

Figure 11